

IMPROVING DESIGN COMMUNICATION WITH TRACEABLE ENGINEERING DESIGN INFORMATION

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1. Introduction

The traditional engineering and manufacturing industry business model – based on delivery of the product – is beginning to be replaced by one where the emphasis is shifting progressively from supply of the product to product supply and provision of support services throughout the product's service life. The shift in emphasis from product delivery to product-service delivery means that the 'provider' becomes more intimately concerned with the product over its life-cycle and involved with the product over a longer time span. This in turn requires that engineering design information (EDI) development has to remain traceable (so that the EDI is made more accessible, understandable and reusable) throughout the decades that a product remains in service (Sivaloganathan and Shahin 1998).

Little is currently understood about the requirements for information traceability in engineering design and there are few methods by which effective traceability can be ensured. There are many similarities and overlapping issues between traceability issues and design rationale capturing. Design rationale capturing tools are beginning to be accepted in industry, e.g. the Design Rationale editor (DRed) developed by Engineering Design Centre (EDC) of Cambridge University (Bracewell et al. 2009).

2. Traceability difficulties in engineering design

Why is the achievement of EDI development traceability in modern highly-automated product development environments, still so difficult? The authors contend that the reason has as much to do with processes and human factors as with issues of heterogeneous tools and distributed teams. However, the current engineering design environment frequently militates against traceability since people exchange engineering information across corporate and discipline boundaries, they reuse existing information in new and unpredictable contexts and often information is transposed from one format

to another during which information loss occurs. Furthermore, because of lack of the formal representations of the complex engineering design information, these exchanges still partly occur informally. As a consequence, retrieval of the engineering design information objects (e.g. with respect to format, type, and contents) as well as correct interpretation of its content (due to the specific domain context) is hindered. This, amongst other things, impedes product innovation and produces unnecessary development iterations.

The existing practice of recording the outcome of the engineering design process is almost exclusively based upon highly formalised model of the product, in the form of computer-aided engineering models, bills of materials, engineering change orders, etc. However, the detailed process, activities and rationale by which the design has been created and the EDI developed are – to the extent that they are recorded at all – are recorded largely in an informal manner (Gies and Goh 2007). A consequence is that is difficult to retrace or audit the engineering reasoning that has taken place during the process of EDI development without extensive work to assimilate and digest design documentation, and that identification of relevant parts of the information records within the documentation requires significant skill and often an intimate knowledge.

3. Research questions and goals

It is the central proposition of this research that more useful traceability of EDI development may be obtained by formal description of the different EDI development dimensions. Consequently, the main goals of the research presented here are:

- Development of the concepts associated with traceability and incorporation of them into a number of explanatory models of traceability practice in engineering design.

- Building of the formal language for description of the information objects' development traceability in engineering design. This constitutes ontology.

- Development of the tools and methods for visualization and communication of information objects' development traceability using the proposed formal language.

Little is currently understood about the requirements for information traceability in engineering design and there are few methods by which effective traceability can be ensured. Therefore we propose the following research questions:

- When and how the requirements for tracing occur? What are the situations that trigger them?

Which are most common "starting points" for tracing in current engineering practice – how they could be structured?

What is most often being looked for, and what is expected to be found?

In which form the answers are needed?

What are the questions and requirements in most common "tracing" situations?

How to structure information fragments in information objects regarding to various contexts and phases of product development process?

How to represent and record informal information in traceability process?

Based on the background research done, the following statements can be derived in order to describe disciplinary angles and nature of research:

Information that is important in a given context according to the engineering design practitioner is recorded in one or more information objects during the information transformation-intensive engineering design process. *We have to investigate how to trace information fragments through more information objects*

Traceability refers to process which combines the contextualization of information objects with an audit trail of the development of the information object. *We have to make explicit and visible the information object's background, sources and foundation.*

The contextualization and audit trail of information objects in engineering design is carried out in order to allow assessment of the credibility of the information objects during the processes which result in their creation.

Information object development refers to the information object life described as intentional informational transformation performed as a cognitive activity by the engineering design practitioners which result in a change in information object content.

Information content is characterized by its quality and quantity that are assessed by quantity (maturity, complexity, etc.) and quality criteria (correctness, clarity, etc.), among which is traceability.

As discussed above, analysis of the concept of traceability has led the authors to the conclusion that a prerequisite for successfully traceability is a formal language for the representation of traceable items, consisting of a well-defined syntax and semantics. It is concluded also that the greater the extent that semantics are defined for traceable activities and objects, the greater the 'intelligence' that can be brought to bear in tracing information development. Thus, both syntactic and semantic information is needed to successfully implement tracing, because it is not enough to know only the form, it is also necessary to know the meaning of traces.

There are several directions and challenges for further research:

- To explore traceability patterns as a medium to communicate experience-based traceability best practices defined in a uniform way – of especially interest would be building research on traceability scenarios based on the engineering activities patterns for particular types of the engineering design.
- To investigate engineering design information object patterns in order to find and represent common elements of design information object structure in a form that is meaningful for tracing.
- To explore active traceability mechanisms in order to support engineers in tracing information object development with minimum extra effort, especially where tracing information can be recorded automatically.
- To investigate distributed traceability mechanisms for making information object content and context reusable across heterogeneous engineering systems.

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